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(54) RARE EARTH ALLOY POWDER FOR RERMANENT MAGNET AND METHOD FOR MANUFACTURING RARE EARTH PERMANENT MAGNET

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a method to add Co, Cu, Dy, etc. to rare earth alloy permanent magnetic powder material which can fully utilize the conventional rare earth material alloy with no change to it, achieving a high magnetic properties but causing neither generation of coarse grain growth nor reduction in coercive force when it is sintered later on.
SOLUTION: This invention relates to production methods for rare earth alloy powder and for permanent magnets using the powder. For the rare earth alloy powder, the first alloy group is defined to contain 29-33 mass % of R (the rare earth element(s) containing at least one or more of rare earth elements, including Y), 0.8-1.2 mass % of B, a combination of 0.01-0.5 mass % of Ga and 0.01-2.0 mass % of Al added for compound effect, and remainder being Fe, and the second alloy group is defined to contain 29-33 mass % of R (the rare earth element(s) containing at least one or more of rare earth elements, including Y), a combination of 0.01-0.5 mass % of Ga and 0.01-2.0 mass % of Al added for compound effect, and remainder being Fe (A part of Fe can be replaced by Co and Cu). This invention features production methods for rare earth alloy powder mixed of the first and second alloy group powders and for permanent magnets using the powder.

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(54)【発明の名称】　希土類永久磁石用合金粉末および希土類永久磁石の製造方法

(57)【要約】
【課題】　本発明は、Ｃｏ、Ｃｕ、Ｄｙ等を添加する方法において、従来の希土類量原料合金を何ら変更することなく十分活用でき、かつ焼結時の粗大結晶粒の発生および保磁力の低下を招来せず、高い磁気特性を達成することを目的とする。
【解決手段】　本発明は、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合されていることを特徴とする希土類合金粉末、それを用いた希土類永久磁石の製造方法である。

【特許請求の範囲】
【請求項１】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合されていることを特徴とする希土類合金粉末。
【請求項２】　ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２であることを特徴とする請求項１記載の希土類合金粉末。
【請求項３】　前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上と、第２合金粉末が、所定組成に混合されていることを特徴とする請求項１記載の希土類合金粉末。
【請求項４】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、
次いで焼結することを特徴とする希土類永久磁石の製造方法。
【請求項５】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換し、ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、
次いで焼結することを特徴とする希土類永久磁石の製造方法。
【請求項６】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金であって、前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、
次いで焼結することを特徴とする希土類永久磁石の製造方法。
【請求項７】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８ｍａｓｓ％未満、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合されていることを特徴とする希土類合金粉末。
【請求項８】　ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２であることを特徴とする請求項７記載の希土類合金粉末。
【請求項９】　前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上と、
第２合金粉末が、所定組成に混合されていることを特徴とする請求項７記載の希土類合金粉末。
【請求項１０】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８ｍａｓｓ％未満、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合された希

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土類合金粉末を磁場中で成形し、
次いで焼結することを特徴とする希土類永久磁石の製造方法。

【請求項１１】　Ｒ（Ｙを含む希土類元素の少なくとも1種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８ｍａｓｓ％未満、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換し、ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、
次いで焼結することを特徴とする希土類永久磁石の製造方法。

【請求項１２】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金であって、前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８ｍａｓｓ％未満、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、
次いで焼結することを特徴とする希土類永久磁石の製造方法。

【請求項１３】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合されていることを特徴とする希土類合金粉末。

【請求項１４】　ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２であることを特徴とする請求項１３記載の希土類合金粉末。

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【請求項１５】　前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上と、
第２合金粉末が、所定組成に混合されていることを特徴とする請求項１３記載の希土類合金粉末。

【請求項１６】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、
次いで焼結することを特徴とする希土類永久磁石の製造方法。

【請求項１７】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換し、ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、
次いで焼結することを特徴とする希土類永久磁石の製造方法。

【請求項１８】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金であって、前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、
次いで焼結することを特徴とする希土類永久磁石の製造方法。

【請求項１９】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～

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３３ｍａｓｓ％、硼素Ｂ０．８ｍａｓｓ％未満、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合されていることを特徴とする希土類合金粉末。
【請求項２０】　ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２であることを特徴とする請求項１９記載の希土類合金粉末。
【請求項２１】　前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上と、
第２合金粉末が、所定組成に混合されていることを特徴とする請求項１９記載の希土類合金粉末。
【請求項２２】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８ｍａｓｓ％未満、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、
次いで焼結することを特徴とする希土類永久磁石の製造方法。
【請求項２３】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８ｍａｓｓ％未満、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換し、ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、
次いで焼結することを特徴とする希土類永久磁石の製造方法。
【請求項２４】　Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金であって、前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上を第１合金とし、
Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８ｍａｓｓ％未満、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、
第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、
次いで焼結することを特徴とする希土類永久磁石の製造方法。

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【発明の詳細な説明】
【０００１】
【発明が属する技術分野】本発明は、Ｒ－Ｔ－Ｂ（Ｒは希土類、Ｔは遷移金属など、Ｂは硼素）系永久磁石用合金粉末と、これを用いたＲ－Ｔ－Ｂ系永久磁石の製造方法に関する。
【０００２】
【従来の技術】今日、Ｒ－Ｔ－Ｂ系永久磁石は各種家電製品、情報通信機器、コンピュータ周辺機器、各種モータといった幅広い分野で使用され、これら製品群の小型化、高速化および使用環境の拡大に合わせて、用いられる磁石も、磁気特性、耐熱性、耐食性の更なる向上が望まれている。
【０００３】Ｒ－Ｔ－Ｂ系永久磁石は、原料合金を溶解し、得られたインゴットを粉砕、成形、焼結、熱処理、加工して製造される。粉砕はボールミル等を用いた湿式粉砕も可能であるが、不活性高圧ガスを用いたジェットミル粉砕が一般的である。このようにして得られる微粉は極めて活性であるため、ジェットミルの粉砕気流中に微量の酸素を混合して安定化を図ったり、または鉱物油などに微粉を回収する方法が採られている。磁場中で行なう成形は、乾式成形、湿式成形いずれも用いられている。焼結は、１０００℃～１１５０℃の温度範囲で真空中あるいは不活性ガス中で行われ、次いで得られた焼結体は適当な温度で１回または複数回の熱処理を施すのが一般的である。
【０００４】Ｒ－Ｔ－Ｂ系永久磁石は、当初は耐食性、耐熱性が低いという問題があったが、添加元素の検討、メッキ等のコーティング技術の発展により著しく改善されてきた。また、磁石素材そのものの耐食性改善も、コーティング後の信頼性を高める上で極めて重要であり、種々の添加元素が検討されている。これらの添加元素としてＣｏ、Ｄｙといった元素が一般的に用いられている。Ｃｏはキュリー温度を上昇させ温度特性を改善し、またＲリッチ相をR_3Co金属間化合物とすることにより耐食性を改善する。Ｄｙは主相の異方性磁界H_Aを増加させることにより保磁力を向上させる。さらにＣｕ、Ｇａ、Ａｌといった微量添加元素も用いられている。ＣｕはＣｏと複合添加することにより最適熱処理範囲を広げ、かつ保磁力向上に寄与する（特開平１－２１９１４３）。また、Ｃｕの添加により粒界相がＲ－Ｃｏ－Ｃｕ金属間化合物になりＣｏ添加のみの場合に比べ、更に耐食性が増すことが知られている。Ｇａ、Ａｌ等の添加元

素も保磁力の向上に効果があることが知られている。

【０００５】Ｃｏ、Ｄｙ、Ｃｕ等の添加方法としては、原料合金の溶解段階で添加する、いわゆる１合金法と、所定組成の合金を、粗粉砕後または微粉砕後に混合する２合金法（混合法）が用いられている。２合金法では粉末の酸化防止を目的に、Ｃｏ、Ｄｙといった耐食性に寄与する元素をＲリッチな合金に添加し、特に、Ｒリッチ合金を特定の結晶構造を持った金属間化合物とすることにより、合金粉末の耐酸化性が増すことが示されている（特開平５－１８２８１３～１８２８１６）。また、保磁力の向上に寄与する、Ｃｕ，Ａｌ，Ｇａなどの元素を粒界相に集中させることを意図し、これらの元素をＲリッチ合金側へ添加する方法が示されている。

【０００６】

【発明が解決しようとする課題】Ｃｏ、Ｄｙ、Ｃｕ等の添加は耐食性、耐熱性の改善に効果があるが、１合金法を用いた場合、ＣｏおよびＣｕを添加すると、高い残留磁束密度が要求されるＤｙの少ない組成域において、焼結時の粒成長が起こりやすく、粗大結晶粒が多く現れる傾向にある。その結果、焼結体の主相結晶粒の粒径分布が広くなり、保磁力、角型性の低下を招きやすいという問題があった。また、２合金法は高性能化の観点から大変魅力的な方法であるが、これを量産規模で実施しようとすると次のような問題点があげられる。すなわち、希土類量の少ない主相合金と希土類に富んだいわゆるＲリッチ合金を用意せねばならず、原料合金系の大幅な変更が求められる。また、主相合金とＲリッチ合金は水素吸蔵特性が異なるために粗粉砕条件の変更が必要であり、また微粉砕性が異なるために混合粗粉をジェットミル粉砕する場合、Ｒリッチ合金が飛散しやすく、また微粉砕後に混合する場合は、それぞれの粉砕条件を別個最適化しなければならないだけでなく、工程が複雑になってしまう。

【０００７】本発明は、Ｃｏ、Ｃｕ、Ｄｙ等を添加する方法において、従来の希土類量原料合金を何ら変更することなく十分活用でき、かつ焼結時の粗大結晶粒の発生および保磁力の低下を招来せず、高い磁気特性を達成することができるＲ－Ｔ－Ｂ系永久磁石用合金粉末およびＲ－Ｔ－Ｂ系永久磁石の製造方法を提供することを目的とする。

【０００８】

【課題を解決するための手段】本発明は、上記の課題を解決するために、下記の構成を主旨とする。なお、下記（１）～（６）は、ＧａとＡｌの複合添加効果を利用して、第２合金の硼素Ｂ添加量を実質的にゼロとした場合である。下記（７）～（１２）は、ＧａとＡｌの複合添加効果を利用して、第２合金の硼素Ｂ添加量を０．８ｍａｓｓ％未満とした場合である。また、下記（１３）～（１８）は、Ａｌを単独添加して第２合金の硼素Ｂ添加量を実質的にゼロとした場合である。下記（１９）～（２４）は、Ａｌを単独添加して、第２合金の硼素Ｂ添加量を０．８ｍａｓｓ％未満とした場合である。

（１）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合されていることを特徴とする希土類合金粉末である。

（２）ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２であることを特徴とする（１）記載の希土類合金粉末である。

（３）前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上と、第２合金粉末が、所定組成に混合されていることを特徴とする（１）記載の希土類合金粉末である。

（４）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、次いで焼結することを特徴とする希土類永久磁石の製造方法である。

（５）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換し、ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、次いで焼結することを特徴とする希土類永久磁石の製造方法である。

（６）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）

２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、　ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金であって、　前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、　ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、次いで焼結することを特徴とする希土類永久磁石の製造方法である。

（７）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、　ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、　硼素Ｂ０．８ｍａｓｓ％未満、　ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合されていることを特徴とする希土類合金粉末である。

（８）ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２であることを特徴とする（７）記載の希土類合金粉末である。

（９）前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上と、第２合金粉末が、所定組成に混合されていることを特徴とする（７）記載の希土類合金粉末である。

（１０）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、　ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、　硼素Ｂ０．８ｍａｓｓ％未満、　ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、次いで焼結することを特徴とする希土類永久磁石の製造方法である。

（１１）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、　ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、　硼素Ｂ０．８ｍａｓｓ％未満、　ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換し、ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、次いで焼結することを特徴とする希土類永久磁石の製造方法である。

（１２）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、　ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金であって、前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、　硼素Ｂ０．８ｍａｓｓ％未満、　ＧａとＡｌを複合添加してＧａ０．０１～０．５ｍａｓｓ％及びＡｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、次いで焼結することを特徴とする希土類永久磁石の製造方法である。

（１３）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合されていることを特徴とする希土類合金粉末である。

（１４）ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２であることを特徴とする（１３）記載の希土類合金粉末である。

（１５）前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上と、第２合金粉末が、所定組成に混合されていることを特徴とする（１３）記載の希土類合金粉末である。

（１６）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、Ａｌ０．

０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、次いで焼結することを特徴とする希土類永久磁石の製造方法である。

（１７）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換し、ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、次いで焼結することを特徴とする希土類永久磁石の製造方法である。

（１８）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金であって、 前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、次いで焼結することを特徴とする希土類永久磁石の製造方法である。

（１９）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、 硼素Ｂ０．８ｍａｓｓ％未満、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合されていることを特徴とする希土類合金粉末である。

（２０）ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２であることを特徴とする（１９）記載の希土類合金粉末である。

（２１）前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上と、第２合金粉末が、所定組成に混合されていることを特徴とする（１９）記載の希土類合金粉末である。

（２２）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、 硼素Ｂ０．８ｍａｓｓ％未満、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、次いで焼結することを特徴とする希土類永久磁石の製造方法である。

（２３）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、 硼素Ｂ０．８ｍａｓｓ％未満、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換し、ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、次いで焼結することを特徴とする希土類永久磁石の製造方法である。

（２４）Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、硼素Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅからなる合金であって、 前記Ｒのうち重希土類の含有量が異なる第１合金粗粉、並びに硼素Ｂ量の異なる第１合金粗粉の第１合金粉末の２種以上を第１合金とし、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、 硼素Ｂ０．８ｍａｓｓ％未満、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合された希土類合金粉末を磁場中で成形し、次いで焼結することを特徴とする希土類永久磁石の製造方法である。

【０００９】（作用）この発明は上記問題点を解決する手段として、２合金法における、Ｃｏ、Ｃｕ、Ｄｙ、Ｂの添加方法および希土類量を検討した結果、Ｃｏ、Ｃｕを含まない従来希土類量の合金粗粉を第１合金とし、これに、第１合金と基本的に希土類量は等しく、Ｂを実質的に含まないか、または第１合金よりも少ない第２合金に特定比率のＣｏ、Ｃｕを添加し、これらの合金粗粉を混合後微粉砕、焼結することにより、従来の希土類量原料合金を何ら変更することなく十分活用でき、かつ焼結時の粗大結晶粒の発生および保磁力の低下を招来せず、耐食性、耐熱性の向上および高い磁気特性を達成することができることを見出したものである。さらに、Ｄｙ、Ｂ等の組成の異なる複数の合金粗粉を第２合金と混合する方法により、混合比を変えるだけで成分調整が容易に行なえることを見出したものである。

【００１０】すなわち、この発明はＲ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、Ｂ

０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅおよび不可避不純物からなる合金を第１合金とし、第１合金と実質的に等しいＲ量、Ｂ０．８ｍａｓｓ％未満、Ａｌ０．０１～２．０ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）および不可避不純物からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合されているＲ－Ｔ－Ｂ系合金粉末である。また、Ｒ（Ｙを含む希土類元素の少なくとも１種以上）２９～３３ｍａｓｓ％、Ｂ０．８～１．２ｍａｓｓ％、Ａｌ０．０１～２．０ｍａｓｓ％、Ｇａ０．０１～０．５ｍａｓｓ％、残部Ｆｅおよび不可避不純物からなる合金を第１合金とし、第１合金と実質的に等しいＲ量、Ｂ０．８ｍａｓｓ％未満、Ａｌ０．０１～２．０ｍａｓｓ％、Ｇａ０．０１～０．５ｍａｓｓ％、残部Ｆｅ（Ｆｅの一部をＣｏおよびＣｕで置換したもの）および不可避不純物からなる合金を第２合金とし、第１合金粉末と第２合金粉末が所定組成に混合されているＲ－Ｔ－Ｂ系合金粉末である。また、ＣｕとＣｏの重量比がＣｕ／Ｃｏ＝０．０２～０．２である上記Ｒ－Ｔ－Ｂ系合金粉末である。また、重希土類量の異なる第１合金粉末２種以上と第２合金粉末が、所定組成に混合されているＲ－Ｔ－Ｂ系合金粉末である。更に、これらのＲ－Ｔ－Ｂ系合金粉末を磁場中で成形し、次いで焼結するＲ－Ｔ－Ｂ系永久磁石の製造方法である。

【００１１】

【発明の実施の形態】この発明において、ＲはＹを含む希土類元素の少なくとも１種以上で、Ｎｄ、Ｐｒ、Ｄｙが好ましい。Ｎｄ、Ｄｙのみでも良いがＮｄ，Ｐｒの混合物をＮｄの代わりに用いても良い。主体となる第１合金のＲは、２９ｍａｓｓ％未満では液相が不足するために焼結不良となり、３３ｍａｓｓ％を超えると残留磁束密度が低下するため、添加量は２９ｍａｓｓ％～３３ｍａｓｓ％とする。第１合金のＢは０．８ｍａｓｓ％未満ではR_2T_{17}相が出現するために保磁力が急減し、１．２ｍａｓｓ％を超えると非磁性相であるＢリッチ相が多くなりすぎてしまい残留磁束密度が低下するので０．８～１．２ｍａｓｓ％とする。第１合金にＡｌまたはＡｌ，Ｇａを添加する場合、Ａｌ、Ｇａ量はＡｌ０．０１～２．０ｍａｓｓ％、Ｇａ０．０１～０．５ｍａｓｓ％とする。Ａｌは保磁力向上の効果を示すが、０．０１ｍａｓｓ％未満ではその効果が十分ではなく２．０ｍａｓｓ％を超えると残留磁束密度の低下が大きく好ましくない。Ｇａも同様にその添加によって保磁力が向上するが、やはり０．０１ｍａｓｓ％未満ではその効果が不十分であり、０．５ｍａｓｓ％を超えると保磁力向上の効果が飽和するとともに残留磁束密度が低下する。本発明においてＧａとＡｌは複合添加すると、より効果的である。

【００１２】第２合金のＲは基本的には第１合金と等しくするが、合金調達の都合やロットバラツキ等で多少ずれてもかまわない。組成範囲は第１合金と等しくＲ２９～３３ｍａｓｓ％とする。第２合金のＢ量は０．８ｍａｓｓ％以上では、粗大粒の発生を抑制する効果が小さくなってしまい保磁力の減少、角型性の悪化を招く。したがって０．８ｍａｓｓ％未満とするが、好ましくはＢを添加しない。第２合金のＧａ、Ａｌは基本的には第１合金と等しくするが、合金調達の都合やロットバラツキ等で多少ずれてもかまわない。ＡｌまたはＡｌ，Ｇａを添加する場合、組成範囲は第１合金と等しくＡｌ０．０１～２．０ｍａｓｓ％、Ｇａ０．０１～０．５ｍａｓｓ％とする。なお、本発明においてＧａとＡｌは複合添加すると、より効果的である。第２合金のＣｏ、Ｃｕの添加量は特に限定されず、最終組成における添加量と配合比の関係から設定でき、最終組成における添加量は用途、目的に応じて設定できる。一方、第１合金に対する第２合金の配合比は、第１合金：第２合金＝９９：１～７０：３０が好ましいが、これも特に限定はされない。

【００１３】ＣｕとＣｏの重量比はＣｕ／Ｃｏが０．０２未満であると熱処理温度範囲を広げる効果が小さく、０．２を超えると、Ｃｏが２ｍａｓｓ％程度のごく一般的な組成において、残留磁束密度の低下、角型性の低下を招く。したがってＣｕ／Ｃｏ＝０．０２～０．２とする。

【００１４】本発明における第１合金粗粉は単一組成のものに限らない。すなわち、Ｄｙ、Ｔｂなどの重希土類量が異なる第１合金粗粉、更にＢ量の異なる第１合金粗粉、これら２種以上に対して、Ｃｏ、Ｃｕの添加された第２合金粗粉を配合し混合しても良い。この場合、ＤｙやＢの調整は配合比を変えるだけで簡単に行なうことができる。

【００１５】

【実施例】以下、本発明の具体的実施例を示し、本発明の内容を詳細に説明する。

(実施例１)Ｎｄ２５．３ｍａｓｓ％、Ｐｒ７．０ｍａｓｓ％、Ｂ１．０ｍａｓｓ％、Ａｌ０．０７ｍａｓｓ％、残部Ｆｅよりなる合金をストリップキャスト法で鋳造した。この合金を処理容器に装入し、真空中で１０００℃×２ｈの熱処理を施した後、水素吸蔵法により解砕して原料粗粉とした(表１記載、合金Ａ)。また、Ｎｄ１８．６ｍａｓｓ％、Ｐｒ５．２ｍａｓｓ％、Ｄｙ８．５ｍａｓｓ％、Ｃｏ２０ｍａｓｓ％、Ｃｕ１ｍａｓｓ％、Ａｌ０．０７ｍａｓｓ％、残部Ｆｅからなる合金も同様にして原料粗粉とした(表１記載、合金Ｉ)。この２種類の合金粗粉を合金Ａ９０ｍａｓｓ％、合金Ｉ１０ｍａｓｓ％の割合でＶ型混合機に投入し、１５分間混合した。この混合粗粉を窒素高圧ガスを用いたジェットミルにて、平均粒径４．７μｍとなるように粉砕した。得られた混合微粉を０．６ＭＡ/ｍの磁場中で配向させながら、１．０Ｔｏｎ/ｃｍ^{2}の圧力で成形した。得られた成形体

は、真空中にて１０６０℃、１０８０℃、または１１００℃×２時間の焼結を行なった。次いで、これらの焼結体は、Ａｒ雰囲気中で９００℃×１時間の熱処理を施した後、さらに４８０℃×１時間の熱処理を施した。焼結体の外観を観察後、磁気特性を測定した。最も角型性の高い場合の磁気特性、焼結温度および外観観察の結果を表１に示す。磁気特性は良好な値が得られ、このとき焼結温度は１１００℃であり、また粗大粒などは見られなかった。

【００１６】（比較例１）本実施例の最終組成である、Ｎｄ２４．６ｍａｓｓ％、Ｐｒ６．８５ｍａｓｓ％、Ｄｙ０．８５ｍａｓｓ％、Ｂ０．９ｍａｓｓ％、Ｃｏ２ｍａｓｓ％、Ｃｕ０．１ｍａｓｓ％、Ａｌ０．０７ｍａｓｓ％、残部Ｆｅよりなる合金をストリップキャスト法で鋳造し、実施例１と同様に粉砕、焼結、熱処理を行なった。得られた焼結体の外観を観察後、磁気特性を測定し、最も角型性の高い場合の磁気特性、焼結温度および外観観察の結果を表１に示す。１０６０℃、１０８０℃、１１００℃のうち最適な焼結温度は１０８０℃であったが、Ｈｃｊが実施例１よりも低く、また粗大粒が観察された。また、１０６０℃の試料は明らかに焼結不足であった。

【００１７】（比較例２）表１に示した合金Ｒと合金Ｓを用いて実施例１と同様に粗粉砕し、最終組成となるよう混合後、微粉砕、焼結、熱処理を行なった。ここで、Ｃｏ，Ｃｕは両合金に一様に添加し、Ｄｙは合金Ｓに添加した。得られた焼結体の外観を観察後、磁気特性を測定し、最も角型性の高い場合の磁気特性、焼結温度および外観観察の結果を表１に示す。Ｈｃｊが実施例１よりも低く、また粗大粒が観察された。

【００１８】（比較例３）表１に示した合金Ｃと合金Ｑを用いて実施例１と同様に粗粉砕し、最終組成となるよう混合後、微粉砕、焼結、熱処理を行なった。ここで、Ｄｙ，Ｃｏ，Ｃｕは合金Ｑに添加し、Ｂは両合金とも一様に添加した。得られた焼結体の外観を観察後、磁気特性を測定し、最も角型性の高い場合の磁気特性、焼結温度および外観観察の結果を表１に示す。Ｈｃｊが実施例１よりも低く、また粗大粒は比較例１，２より少ないが観察された。

【００１９】（実施例２）表１に示した合金Ａと合金Ｋを用いて実施例１と同様に粗粉砕し、最終組成となるよう混合後、微粉砕、焼結、熱処理を行なった。ここで、Ｄｙ，Ｃｏ，Ｃｕは合金Ｋに添加しＢは０．４ｍａｓｓ％とした。合金Ｋは本発明の第２合金である。得られた焼結体の外観を観察後、磁気特性を測定し、最も角型性の高い場合の磁気特性、焼結温度および外観観察の結果を表１に示す。磁気特性は実施例１と同様に良好な値が得られ、このとき焼結温度は１１００℃であり、また粗大粒などは見られなかった。

【００２０】（実施例３）表１に示した合金Ａと合金Ｌを用いて実施例１と同様に粗粉砕し、最終組成となるよう混合後、微粉砕、焼結、熱処理を行なった。ここで、Ｄｙ，Ｃｏ，Ｃｕは合金Ｌに添加しＢは０．７ｍａｓｓ％とした。合金Ｌは本発明の第２合金である。得られた焼結体の外観を観察後、磁気特性を測定し、最も角型性の高い場合の磁気特性、焼結温度および外観観察の結果を表１に示す。磁気特性は実施例１と同様に良好な値が得られ、このとき焼結温度は１１００℃であり、また粗大粒などは見られなかった。

【００２１】（実施例４）表１に示した合金Ｂと合金Ｃと合金Ｉを用いて実施例１と同様に粗粉砕し、最終組成となるよう混合後、微粉砕、焼結、熱処理を行なった。ここで、Ｄｙ，Ｃｏ，Ｃｕは合金Ｉに添加しＢは無添加とした。合金Ｉは本発明の第２合金である。得られた焼結体の外観を観察後、磁気特性を測定し、最も角型性の高い場合の磁気特性、焼結温度および外観観察の結果を表１に示す。磁気特性は実施例１と同様に良好な値が得られ、このとき焼結温度は１１００℃であり、また粗大粒などは見られなかった。

【００２２】（実施例５）表１に示した合金Ｂと合金Ｃと合金Ｄと合金Ｊを用いて実施例１と同様に粗粉砕し、最終組成となるよう混合後、微粉砕、焼結、熱処理を行なった。ここで、Ｃｏ，Ｃｕは合金Ｊに添加しＢは無添加とした。合金Ｊは本発明の第２合金である。Ｄｙは本発明の第１合金の一つである合金Ｄにより添加した。得られた焼結体の外観を観察後、磁気特性を測定し、最も角型性の高い場合の磁気特性、焼結温度および外観観察の結果を表１に示す。磁気特性は実施例１と同様に良好な値が得られ、このとき焼結温度は１１００℃であり、また粗大粒などは見られなかった。

【００２３】（比較例４）表１に示した合金Ｔと合金Ｕを用いて実施例１と同様に粗粉砕し、最終組成となるよう混合後、微粉砕、焼結、熱処理を行なった。ここで、Ｄｙ、Ｃｏ、ＣｕはＲリッチな合金Ｕに添加しＢは無添加とした。合金Ｕは本発明の第２合金ではない。得られた焼結体の外観を観察後、磁気特性を測定し、最も角型性の高い場合の磁気特性、焼結温度および外観観察の結果を表１に示す。磁気特性は実施例１と同様に良好な値が得られ、このとき焼結温度は１１００℃であり、また粗大粒などは見られなかった。この結果から、実施例１～５で得られる磁気特性は、従来の２合金法（比較例４）と同等のものであることが分かる。

【００２４】（実施例６～１０、比較例５～８）第１合金Ａ～Ｄ、第２合金Ｉ～Ｌ、比較用合金Ｐ～Ｕの組成において、Ｇａを０．１ｍａｓｓ％添加した合金を新たに作製し、第１合金Ａ’～Ｄ’、第２合金Ｉ’～Ｌ’、比較用合金Ｐ’～Ｕ’とした。実施例１～５、比較例１～４と同様の方法で焼結体を作製し、焼結体の外観を観察後、磁気特性を測定した。最も角型性の高い場合の磁気特性、焼結温度および外観観察の結果を表２に示す。最

適焼結温度、粗大粒の外観に関しては表１の結果と同様であるが、Ｈｃｊの水準は０．２ＭＡ／m程度向上することが確認できる。Ｇａの複合添加効果が出ている。

【００２５】

【表１】

		組成 (mass%)							
		Nd	Pr	Dy	TRE	B	Co	Cu	Fe
第1合金	A	25.3	7.0	0	32.3	1.00	0	0	bal.
	B	25.2	7.0	0	32.2	1.07	0	0	bal.
	C	25.3	7.0	0	32.3	0.90	0	0	bal.
	D	11.9	3.3	17.0	32.2	1.07	0	0	bal.
第2合金	I	18.6	5.2	8.5	32.3	0	20	1	bal.
	J	25.3	7.0	0	32.3	0	20	1	bal.
	K	20.8	5.7	5.7	32.2	0.4	13.3	0.67	bal.
	L	23.1	6.4	2.8	32.3	0.7	6.7	0.34	bal.
比較合金	P	24.6	6.85	0.85	32.3	0.90	2	0.1	bal.
	Q	18.5	5.2	8.5	32.2	0.90	20	1	bal.
	R	25.3	6.9	0	32.2	0.90	2	0.1	bal.
	S	12.0	3.3	17.0	32.3	1.07	2	0.1	bal.
	T	23.8	6.6	0	30.4	1.03	0	0	bal.
	U	30.1	8.4	7.2	45.7	0	16.9	0.85	bal.
最終組成		24.6	6.85	0.85	32.3	0.90	2	0.1	bal.

Al:0.06〜0.08mass%

	配合(合金×配合率)	Br (T)	Hcj (MA/	Hk/Hc (%)	最適焼温度	粗大粒外観
実施例	A×0.9＋I×0.1	1.36	1.17	98.3	1100	○
比較例	P	1.35	1.01	98.1	1080	×
比較例	R×0.95＋S×0.05	1.35	1.0	98.2	1080	×
比較例	C×0.9＋Q×0.1	1.35	1.03	98.1	1080	△
実施例	A×0.85＋K×0.15	1.35	1.16	98.0	1100	○
実施例	A×0.7＋L×0.3	1.36	1.16	97.8	1100	○
実施例	B×0.53＋C×0.37＋I×0.1	1.35	1.17	98.2	1100	○
実施例	B×0.5＋C×0.35＋D×0.05＋J	1.36	1.17	98.4	1100	○
比較例	T×0.88＋U×0.12	1.36	1.18	98.1	1100	○

○:なし △:あり ×:多し

【００２６】

【表２】

	配合(合金×配合率)	Br (T)	Hcj (MA/	Hk/Hc (%)	最適焼温度	粗大粒外観
実施例	A'×0.9＋I'×0.1	1.35	1.38	98.4	1100	○
比較例	P'	1.34	1.21	97.9	1080	×
比較例	R'×0.95＋S'×0.05	1.35	1.22	97.9	1080	×
比較例	C'×0.9＋Q'×0.1	1.35	1.25	98.4	1080	△
実施例	A'×0.85＋K'×0.15	1.35	1.37	98.2	1100	○
実施例	A'×0.7＋L'×0.3	1.35	1.35	98.1	1100	○
実施例	B'×0.53＋C'×0.37＋I'×0.1	1.35	1.38	98.4	1100	○
実施例	B'×0.5＋C'×0.35＋D'×0.05＋	1.36	1.37	98.4	1100	○
比較例	T'×0.88＋U'×0.12	1.35	1.38	98.4	1100	○

○:なし △:あり ×:多し

【００２７】

【発明の効果】本発明によれば、Ｃｏ、Ｃｕ、Ｄｙ等を添加する方法において、従来の希土類量の原料合金を何ら変更することなく十分活用でき、かつ焼結時の粗大結晶粒の発生および保磁力の低下を招来せず、高い磁気特性を達成することができる。

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(54) RARE EARTH ALLOY POWDER FOR RERMANENT MAGNET AND METHOD FOR MANUFACTURING RARE EARTH PERMANENT MAGNET

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a method to add Co, Cu, Dy, etc. to rare earth alloy permanent magnetic powder material which can fully utilize the conventional rare earth material alloy with no change to it, achieving a high magnetic properties but causing neither generation of coarse grain growth nor reduction in coercive force when it is sintered later on.
SOLUTION: This invention relates to production methods for rare earth alloy powder and for permanent magnets using the powder. For the rare earth alloy powder, the first alloy group is defined to contain 29-33 mass % of R (the rare earth element(s) containing at least one or more of rare earth elements, including Y), 0.8-1.2 mass % of B, a combination of 0.01-0.5 mass % of Ga and 0.01-2.0 mass % of Al added for compound effect, and remainder being Fe, and the second alloy group is defined to contain 29-33 mass % of R (the rare earth element(s) containing at least one or more of rare earth elements, including Y), a combination of 0.01-0.5 mass % of Ga and 0.01-2.0 mass % of Al added for compound effect, and remainder being Fe (A part of Fe can be replaced by Co and Cu). This invention features production methods for rare earth alloy powder mixed of the first and second alloy group powders and for permanent magnets using the powder.

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CLAIMS

[Claim(s)]

[Claim 1] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, Rare earth alloy powder which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by the 1st alloy powder and the 2nd alloy powder

being mixed by the predetermined presentation.

[Claim 2] Rare earth alloy powder according to claim 1 characterized by the weight ratio of Cu and Co being Cu/Co=0.02-0.2.

[Claim 3] Rare earth alloy powder according to claim 1 characterized by the 2nd alloy powder being mixed with two or more sorts of the 1st alloy powder of the 1st alloy coarse powder with which the contents of heavy rare earth differ among said R, and the 1st alloy coarse powder with which the amounts of boron B differ in a list by the predetermined presentation.

[Claim 4] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

[Claim 5] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe (a part of Fe is permuted by Co and Cu, and the weight ratio of Cu and Co is Cu/Co=0.02-0.2) is used as the 2nd alloy. The manufacture approach of the rare earth permanent magnet characterized by fabricating the rare earth alloy powder

with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

[Claim 6] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, It is the alloy which consists of the remainder Fe, the 1st alloy coarse powder with which the contents of heavy rare earth differ among said R, Two or more sorts of the 1st alloy powder of the 1st alloy coarse powder with which the amounts of boron B differ in a list are used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

[Claim 7] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of less than [boron B0.8mass%], and Ga and aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, Rare earth alloy powder which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by the 1st alloy powder and the 2nd alloy powder being mixed by the predetermined presentation.

[Claim 8] Rare earth alloy powder according to claim 7 characterized by the weight ratio of Cu and Co being Cu/Co=0.02-0.2.

[Claim 9] Rare earth alloy powder according to claim 7 characterized by the 2nd alloy powder being mixed with two or more sorts of the 1st alloy powder of the 1st alloy coarse powder with which the contents of heavy rare earth differ among said R, and the 1st alloy coarse powder with which the amounts of boron B differ in a list by the predetermined presentation.

[Claim 10] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of less than [boron B0.8mass%], and Ga and aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

[Claim 11] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of less than [boron B0.8mass%], and Ga and aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe (a part of Fe is permuted by Co and Cu, and the weight ratio of Cu and Co is Cu/Co=0.02-0.2) is used as the 2nd alloy. The manufacture approach of the rare earth permanent magnet characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

[Claim 12] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, It is the alloy which consists of the remainder Fe, the 1st alloy coarse powder with which the contents of heavy rare earth differ among said R, Two or more sorts of the 1st alloy powder of the 1st alloy coarse powder with which the amounts of boron B differ in a list are used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of less than [boron B0.8mass%], and Ga and aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

[Claim 13] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Rare earth alloy powder which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu) aluminum0.01 - 2.0mass%, and is characterized by the 1st alloy powder and the 2nd alloy powder being mixed by the predetermined presentation.

[Claim 14] Rare earth alloy powder according to claim 13 characterized by the weight ratio of Cu and Co being Cu/Co=0.02-0.2.

[Claim 15] Rare earth alloy powder according to claim 13 characterized by the 2nd alloy powder being mixed with two or more sorts of the 1st alloy powder of the 1st alloy coarse powder with which the contents of heavy rare earth differ among said R, and the 1st alloy coarse powder with which the amounts of boron B differ in a list by the predetermined presentation.

[Claim 16] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, The alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu) is used as the 2nd alloy aluminum0.01 - 2.0mass%. The manufacture approach of the rare earth permanent magnet characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

[Claim 17] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, aluminum0.01 - 2.0mass%, Remainder Fe (a part of Fe is permuted by Co and Cu) The manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy with which the weight ratio of Cu and Co consists of Cu/Co=0.02-0.2, and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

[Claim 18] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, It is the alloy which consists of the remainder Fe, the 1st alloy coarse powder with which the contents of heavy rare earth differ among said R, Two or more sorts of the 1st alloy powder of the 1st alloy coarse powder with which the amounts of boron B differ in a list are used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, The alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu) is used as the 2nd alloy aluminum0.01 - 2.0mass%. The manufacture approach of the rare earth permanent magnet characterized by fabricating the rare earth alloy powder with

which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

[Claim 19] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Rare earth alloy powder which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu) less than [boron B0.8mass%] and aluminum0.01 - 2.0mass%, and is characterized by the 1st alloy powder and the 2nd alloy powder being mixed by the predetermined presentation.

[Claim 20] Rare earth alloy powder according to claim 19 characterized by the weight ratio of Cu and Co being Cu/Co=0.02-0.2.

[Claim 21] Rare earth alloy powder according to claim 19 characterized by the 2nd alloy powder being mixed with two or more sorts of the 1st alloy powder of the 1st alloy coarse powder with which the contents of heavy rare earth differ among said R, and the 1st alloy coarse powder with which the amounts of boron B differ in a list by the predetermined presentation.

[Claim 22] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Less than [boron B0.8mass%], aluminum0.01 - 2.0mass%, The manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

[Claim 23] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, The alloy which

consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Less than [boron B0.8mass%], aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe (a part of Fe is permuted by Co and Cu, and the weight ratio of Cu and Co is Cu/Co=0.02-0.2) is used as the 2nd alloy. The manufacture approach of the rare earth permanent magnet characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

[Claim 24] R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, It is the alloy which consists of the remainder Fe, the 1st alloy coarse powder with which the contents of heavy rare earth differ among said R, Two or more sorts of the 1st alloy powder of the 1st alloy coarse powder with which the amounts of boron B differ in a list are used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Less than [boron B0.8mass%], aluminum0.01 - 2.0mass%, The manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

[Translation done.]

2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] This invention relates to the alloy powder for R-T-B (for rare earth and T, B, such as transition metals, is [R] boron) system permanent magnets, and the manufacture approach of a R-T-B system permanent magnet of having used this.

[0002]

[Description of the Prior Art] A R-T-B system permanent magnet is used in broad fields, such as various home electronics, information communication equipment, computer-related peripherals, and various motors, and magnetic properties, thermal resistance, and the further corrosion resistance improvement are desired also for the magnet used today to compensate for the miniaturization of these product groups, improvement in the speed, and expansion of an operating environment.

[0003] A R-T-B system permanent magnet dissolves a raw material alloy, it grinds the obtained ingot, fabricates it, sinters it, heat-treats it, it processes it, and is manufactured. Although wet grinding which used the ball mill etc. is also possible for grinding, jet mill grinding using inactive high pressure gas is common. Thus, since the fines obtained are activity very much, stabilization is attained or the method of mixing the oxygen of a minute amount in the grinding air current of a jet mill, and collecting fines to straight mineral oil etc. is taken. shaping performed all over a magnetic field -- dry pressing and a wet compaction -- all are used. As for the sintered compact which sintering was performed in a vacuum or inert gas in the 1000 degrees C - 1150 degrees C temperature requirement, and was subsequently obtained, it is common to perform heat treatment of 1 time or

multiple times at suitable temperature.

[0004] Although the R-T-B system permanent magnet had the problem that corrosion resistance and thermal resistance were low at the beginning, it has been remarkably improved by development of coating techniques, such as examination of an alloying element and plating. Moreover, the corrosion-resistant improvement of the magnet material itself is also very important when raising the dependability after coating, and various alloying elements are examined. Generally elements, such as Co and Dy, are used as these alloying elements. Co improves corrosion resistance by raising Curie temperature, and improving the temperature characteristic, and using R rich phase as an R3Co intermetallic compound. Dy raises coercive force by making the anisotropy field HA of the main phase increase. Furthermore, additional trace elements, such as Cu, Ga, and aluminum, are also used. By carrying out compound addition with Co, Cu extends the optimal heat treatment range, and contributes to the improvement in coercive force (JP,1-219143,A). Moreover, it is known that a grain boundary phase will become a R-Co-Cu intermetallic compound by addition of Cu, and corrosion resistance will increase further compared with the case of only Co addition. It is known that alloying elements, such as Ga and aluminum, also have effectiveness in improvement in coercive force.

[0005] As the addition approaches, such as Co, Dy, and Cu, one so-called alloying method added in the dissolution phase of a raw material alloy and two alloying methods (alligation) which mix the alloy of a predetermined presentation after coarse grinding or pulverizing are used. the element contributed to corrosion resistance, such as Co and Dy, for the purpose of powdered antioxidizing in two alloying methods -- R -- it is shown by by adding into a rich alloy and using R rich alloy as an intermetallic compound with the specific crystal structure especially that the oxidation resistance of alloy powder increases (JP,5-182813,A -182816). Moreover, it means centralizing elements contributed to improvement in coercive force, such as Cu, aluminum, and Ga, on a grain boundary phase, and the approach of adding these elements to R rich alloy side

is shown.

[0006]

[Problem(s) to be Solved by the Invention] Although addition of Co, Dy, Cu, etc. has effectiveness in corrosion resistance and a heat-resistant improvement, if Co and Cu are added when one alloying method is used, it will set in few presentation regions of Dy where a high residual magnetic flux density is demanded, The grain growth at the time of sintering tends to take place, and it is in the inclination for big and rough crystal grain to appear mostly. Consequently, the particle size distribution of the main phase crystal grain of a sintered compact became large, and there was a problem of being easy to cause the fall of coercive force and square shape nature. Moreover, the following troubles will be got if they tend to carry this out on a scale of mass production, although two alloying methods are very attractive approaches from a viewpoint of high-performance-izing. That is, the main phase alloy with few amounts of rare earth and the so-called R rich alloy which was rich in rare earth must be prepared, and large modification of a raw material alloy system is called for. Moreover, it not only must carry out separate optimization of each grinding condition, but a process will become complicated when the main phase alloy and R rich alloy need modification of coarse-grinding conditions since hydrogen absorption properties differ, and R rich alloy tends to disperse when carrying out jet mill grinding of the mixed coarse powder, since pulverizing nature differs, and mixing after pulverizing.

[0007] In the approach of adding Co, Cu, Dy, etc., it can utilize enough, without changing the conventional amount raw material alloy of rare earth in any way, and this invention does not invite generating of the big and rough crystal grain at the time of sintering, and the fall of coercive force, but aims at offering the manufacture approach of the alloy powder for R-T-B system permanent magnets which can attain high magnetic properties, and a R-T-B system permanent magnet.

[0008]

[Means for Solving the Problem] This invention makes the following configuration main point, in order to solve the above-mentioned technical problem. In addition, following the (1) - (6) is the case where the boron B addition of the 2nd alloy is substantially made into zero using the compound addition effectiveness of Ga and aluminum. Following the (7) - (12) is the case where the boron B addition of the 2nd alloy is made into less than [0.8mass%] using the compound addition effectiveness of Ga and aluminum. Moreover, following the (13) - (18) is the case where carried out independent addition of the aluminum and the boron B addition of the 2nd alloy is substantially made into zero. Following the (19) - (24) is the case where carried out independent addition of the aluminum and the boron B addition of the 2nd alloy is made into less than [0.8mass%].

(1) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, It is the rare earth alloy powder which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by the 1st alloy powder and the 2nd alloy powder being mixed by the predetermined presentation.

(2) It is the rare earth alloy powder given in (1) characterized by the weight ratio of Cu and Co being Cu/Co=0.02-0.2.

(3) said -- R -- inside -- heavy rare earth -- a content -- differing -- the -- one -- an alloy -- coarse powder -- a list -- boron -- B -- an amount -- differing -- the -- one -- an alloy -- coarse powder -- the -- one -- an alloy -- powder -- two -- a sort -- more than -- the -- two -- an alloy -- powder -- predetermined -- a presentation -- mixing -- having -- **** -- things -- the description -- ** -- carrying out -- (-- one --) -- a publication -- a rare earth alloy -- powder -- it is .

(4) R(at least one or more sorts of rare earth elements containing Y) 29 -

33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, It is the manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

(5) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe (a part of Fe is permuted by Co and Cu, and the weight ratio of Cu and Co is Cu/Co=0.02-0.2) is used as the 2nd alloy. It is the manufacture approach of the rare earth permanent magnet characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

(6) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, It is the alloy which consists of the remainder Fe, the 1st alloy coarse powder with which the contents of heavy rare earth differ among said R, Two or more sorts of the 1st alloy powder of the 1st alloy coarse powder with which the amounts of boron B

differ in a list are used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, It is the manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

(7) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of less than [boron B0.8mass%], and Ga and aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, It is the rare earth alloy powder which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by the 1st alloy powder and the 2nd alloy powder being mixed by the predetermined presentation.

(8) It is the rare earth alloy powder given in (7) characterized by the weight ratio of Cu and Co being Cu/Co=0.02-0.2.

(9) said -- R -- inside -- heavy rare earth -- a content -- differing -- the -- one -- an alloy -- coarse powder -- a list -- boron -- B -- an amount -- differing -- the -- one -- an alloy -- coarse powder -- the -- one -- an alloy -- powder -- two -- a sort -- more than -- the -- two -- an alloy -- powder -- predetermined -- a presentation -- mixing -- having -- **** -- things -- the description -- ** -- carrying out -- (-- seven --) -- a publication -- a rare earth alloy -- powder -- it is .

(10) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy

which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of less than [boron B0.8mass%], and Ga and aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, It is the manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

(11) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of less than [boron B0.8mass%], and Ga and aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe (a part of Fe is permuted by Co and Cu, and the weight ratio of Cu and Co is Cu/Co=0.02-0.2) is used as the 2nd alloy. It is the manufacture approach of the rare earth permanent magnet characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

(12) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of Ga and the aluminum is carried out boron B0.8 - 1.2mass%. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, The 1st alloy coarse powder with which it is the alloy which consists of the remainder Fe, and the contents of heavy rare earth differ among said R, Two or more sorts of the 1st alloy powder of the 1st alloy coarse powder with which the amounts of boron B differ in a list are used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Compound addition of less than

[boron B0.8mass%], and Ga and aluminum is carried out. Ga0.01 - 0.5mass% and aluminum0.01 - 2.0mass%, It is the manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

(13) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, It is the rare earth alloy powder which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by the 1st alloy powder and the 2nd alloy powder being mixed by the predetermined presentation aluminum0.01 - 2.0mass%.

(14) It is the rare earth alloy powder given in (13) characterized by the weight ratio of Cu and Co being Cu/Co=0.02-0.2.

(15) said -- R -- inside -- heavy rare earth -- a content -- differing -- the -- one -- an alloy -- coarse powder -- a list -- boron -- B -- an amount -- differing -- the -- one -- an alloy -- coarse powder -- the -- one -- an alloy -- powder -- two -- a sort -- more than -- the -- two -- an alloy -- powder -- predetermined -- a presentation -- mixing -- having -- **** -- things -- the description -- ** -- carrying out -- (-- 13 --) -- a publication -- a rare earth alloy -- powder -- it is .

(16) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, The alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu) is used as the 2nd alloy aluminum0.01 - 2.0mass%. It is the manufacture approach of the rare earth permanent magnet characterized by fabricating the rare earth alloy powder with

which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

(17) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, aluminum0.01 - 2.0mass%, Remainder Fe (a part of Fe is permuted by Co and Cu) It is the manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy with which the weight ratio of Cu and Co consists of Cu/Co=0.02-0.2, and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

(18) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, It is the alloy which consists of the remainder Fe, the 1st alloy coarse powder with which the contents of heavy rare earth differ among said R, Two or more sorts of the 1st alloy powder of the 1st alloy coarse powder with which the amounts of boron B differ in a list are used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, The alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu) is used as the 2nd alloy aluminum0.01 - 2.0mass%. It is the manufacture approach of the rare earth permanent magnet characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.

(19) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, It is the rare earth alloy

powder which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by the 1st alloy powder and the 2nd alloy powder being mixed by the predetermined presentation less than [boron B0.8mass%] and aluminum0.01 - 2.0mass%.
(20) It is the rare earth alloy powder given in (19) characterized by the weight ratio of Cu and Co being Cu/Co=0.02-0.2.
(21) said -- R -- inside -- heavy rare earth -- a content -- differing -- the -- one -- an alloy -- coarse powder -- a list -- boron -- B -- an amount -- differing -- the -- one -- an alloy -- coarse powder -- the -- one -- an alloy -- powder -- two -- a sort -- more than -- the -- two -- an alloy -- powder -- predetermined -- a presentation -- mixing -- having -- **** -- things -- the description -- ** -- carrying out -- (-- 19 --) -- a publication -- a rare earth alloy -- powder -- it is .
(22) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Less than [boron B0.8mass%], aluminum0.01 - 2.0mass%, It is the manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.
(23) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe is used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Less than [boron B0.8mass%], aluminum0.01 - 2.0mass%, The alloy which consists of the remainder Fe (a part of Fe is permuted by Co and Cu, and the weight ratio of Cu and Co is Cu/Co=0.02-0.2) is used as the 2nd alloy. It is the manufacture approach of the rare earth permanent magnet characterized by fabricating the

rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.
(24) R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Boron B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, It is the alloy which consists of the remainder Fe, the 1st alloy coarse powder with which the contents of heavy rare earth differ among said R, Two or more sorts of the 1st alloy powder of the 1st alloy coarse powder with which the amounts of boron B differ in a list are used as the 1st alloy. R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, Less than [boron B0.8mass%], aluminum0.01 - 2.0mass%, It is the manufacture approach of the rare earth permanent magnet which uses as the 2nd alloy the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and is characterized by fabricating the rare earth alloy powder with which the 1st alloy powder and the 2nd alloy powder were mixed by the predetermined presentation all over a magnetic field, and subsequently sintering it.
[0009] (Operation) As a means to solve the above-mentioned trouble, this invention can be set to two alloying methods. As a result of examining the addition approach of Co, Cu, Dy, and B, and the amount of rare earth, Co, Use alloy coarse powder of the amount of rare earth as the 1st alloy conventionally which does not contain Cu, and the amount of rare earth is fundamentally [as the 1st alloy] equal to this. By adding Co of a specific ratio, and Cu into the 2nd alloy fewer than the 1st alloy, excluding B substantially, and pulverizing and sintering after mixing such alloy coarse powder It can utilize enough, without changing the conventional amount raw material alloy of rare earth in any way, generating of the big and rough crystal grain at the time of sintering and the fall of coercive force are not invited, but it finds out that corrosion resistance, heat-resistant improvement, and high magnetic properties can be attained. Furthermore, it finds out that a quality governing can be easily performed only by changing a mixing ratio by the approach of mixing with the 2nd alloy two or more

alloy coarse powder with which presentations, such as Dy and B, differ.

[0010] This invention Namely, R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, The alloy which consists of the remainder Fe and an unescapable impurity is used as the 1st alloy aluminum0.01 - 2.0mass% B0.8 - 1.2mass%. With the 1st alloy, substantially The equal amount of R, less than [B0.8mass%], aluminum0.01 - 2.0mass%, It is the R-T-B system alloy powder with which the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and an unescapable impurity is used as the 2nd alloy, and the 1st alloy powder and the 2nd alloy powder are mixed by the predetermined presentation. Moreover, R(at least one or more sorts of rare earth elements containing Y) 29 - 33mass%, B0.8 - 1.2mass%, aluminum0.01 - 2.0mass%, Ga0.01 - 0.5mass%, The alloy which consists of the remainder Fe and an unescapable impurity is used as the 1st alloy. Substantially with the 1st alloy The equal amount of R, Less than [B0.8mass%], aluminum0.01 - 2.0mass%, Ga0.01 - 0.5mass%, It is the R-T-B system alloy powder with which the alloy which consists of the remainder Fe (what permuted a part of Fe by Co and Cu), and an unescapable impurity is used as the 2nd alloy, and the 1st alloy powder and the 2nd alloy powder are mixed by the predetermined presentation. Moreover, the weight ratio of Cu and Co is the above-mentioned R-T-B system alloy powder which is Cu/Co=0.02-0.2. Moreover, two or more sorts of 1st alloy powder with which the amounts of heavy rare earth differ, and the 2nd alloy powder are R-T-B system alloy powder currently mixed by the predetermined presentation. Furthermore, it is the manufacture approach of the R-T-B system permanent magnet which fabricates these R-T-B system alloy powder all over a magnetic field, and subsequently sinters it.

[0011]

[Embodiment of the Invention] In this invention, R is at least one or more sorts of the rare earth elements containing Y, and Nd, Pr, and its Dy are desirable. Also with Nd and Dy chisel, although it is good, the mixture of Nd and Pr may be used instead of Nd. Since a residual magnetic flux density will fall if it becomes poor

sintering R of the 1st alloy which serves as a subject since the liquid phase runs short less than [29mass%], and it exceeds 33mass%, an addition is made into 29mass(es)% - 33mass%. Less than [0.8mass%], since B rich phase which is a nonmagnetic phase will increase too much and a residual magnetic flux density will fall if coercive force decreases rapidly and 1.2mass% is exceeded, since R2T17 phase appears, B of the 1st alloy may be 0.8 - 1.2mass%. When adding aluminum, or aluminum and Ga into the 1st alloy, aluminum and the amount of Ga(s) are made into Ga0.01 - 0.5mass% aluminum0.01 - 2.0mass%. Although aluminum shows the effectiveness of the improvement in coercive force, if the effectiveness exceeds 2.0mass(es)% rather than is enough, the fall of a residual magnetic flux density is not greatly desirable [aluminum] less than [0.01mass%]. Although coercive force of Ga improves by the addition similarly, if less than [0.01mass%] is inadequate too as for the effectiveness and 0.5mass% is exceeded, while the effectiveness of the improvement in coercive force will be saturated, a residual magnetic flux density falls. It is more effective if Ga and aluminum carry out compound addition in this invention.

[0012] Although R of the 2nd alloy is fundamentally made equal to the 1st alloy, you may shift somewhat with convenience, lot variation, etc. of alloy supply. The presentation range is made into R29 - 33mass% equally to the 1st alloy. More than at 0.8mass%, the effectiveness which controls generating of a big and rough grain becomes small, and the amount of B of the 2nd alloy causes reduction in coercive force, and aggravation of square shape nature. Therefore, although considered as less than [0.8mass%], B is not added preferably. Although Ga of the 2nd alloy and aluminum are fundamentally made equal to the 1st alloy, you may shift somewhat with convenience, lot variation, etc. of alloy supply. When adding aluminum, or aluminum and Ga, the presentation range is made into Ga0.01 - 0.5mass% aluminum0.01 - 2.0mass% equally to the 1st alloy. In addition, it is more effective if Ga and aluminum carry out compound addition in this invention. Co of the 2nd alloy and especially the addition of Cu cannot be limited, but can be set up from the relation between the addition in the last

presentation, and a compounding ratio, and the addition in the last presentation can be set up according to an application and the purpose. the compounding ratio of the 2nd alloy [as opposed to the 1st alloy on the other hand] -- 1st alloy: -- the 2nd -- especially as for limitation, this is not carried out, either, although alloy =99:1-70:30 are desirable.

[0013] If the weight ratio of Cu and Co has the small effectiveness which extends the heat-treatment-temperature range as Cu/Co is less than 0.02 and exceeds 0.2, Co will cause the fall of a residual magnetic flux density, and the fall of square shape nature in the very general presentation which is about 2mass%. Therefore, it is referred to as Cu/Co=0.02-0.2.

[0014] The 1st alloy coarse powder in this invention is not restricted to the thing of a single presentation. That is, to these [the 1st alloy coarse powder with which the amounts of heavy rare earth, such as Dy and Tb, differ, the 1st alloy coarse powder with which the amounts of B differ further and] two or more sorts, the 2nd alloy coarse powder with which Co and Cu were added may be blended, and you may mix. In this case, adjustment of Dy or B can be easily performed only by changing a compounding ratio.

[0015]

[Example] Hereafter, the concrete example of this invention is shown and the contents of this invention are explained to a detail.

(Example 1) The alloy which consists of the remainder Fe was cast in the strip cast method aluminum0.07mass% B1.0mass% Pr7.0mass% Nd25.3mass%. After inserting this alloy in the processing container and performing heat treatment of 1000 degree-Cx2h in a vacuum, it cracked by the hydrogen absorption method and considered as raw material coarse powder (a Table 1 publication, Alloy A). Moreover, the alloy which consists of the remainder Fe was similarly used as raw material coarse powder aluminum0.07mass% Cu1mass% Co20mass% Dy8.5mass% Pr5.2mass% Nd18.6mass% (a Table 1 publication, Alloy I). Two kinds of this alloy coarse powder was thrown into the V shaped rotary mixer at an alloy I10mass% rate alloy A90mass%, and it mixed for 15

minutes. This mixed coarse powder was ground so that it might become the mean particle diameter of 4.7 micrometers with the jet mill using nitrogen high pressure gas. It fabricated by the pressure of 1.0 Ton/cm2, carrying out orientation of the obtained mixed fines all over the magnetic field of 0.6 MA/m. The acquired Plastic solid performed sintering of 1060-degree-C, 1080-degree-C, or 1100 degree-Cx 2 hours in the vacuum. Subsequently, these sintered compacts performed heat treatment of 480 more degree-Cx 1 hour, after performing heat treatment of 900 degree-Cx 1 hour in Ar ambient atmosphere. Magnetic properties were measured after observing the appearance of a sintered compact. The result of magnetic properties when square shape nature is the highest, sintering temperature, and appearance observation is shown in Table 1. The value with good magnetic properties was acquired, sintering temperature is 1100 degrees C at this time, and the big and rough grain etc. was not seen.

[0016] (Example 1 of a comparison) Cu0.1mass%, aluminum0.07mass%, the alloy which consists of the remainder Fe was cast in the strip cast method, and grinding, sintering, and heat treatment were performed like the example 1 Co2mass% B0.9mass% Dy0.85mass% Pr6.85mass% Nd24.6mass% which is the last presentation of this example. Magnetic properties are measured after observing the appearance of the obtained sintered compact, and the result of magnetic properties when square shape nature is the highest, sintering temperature, and appearance observation is shown in Table 1. Although the optimal sintering temperature was 1080 of 1060 degrees C, 1080 degrees C, and 1100 degrees C, Hcj was lower than the example 1, and the big and rough grain was observed. Moreover, sintering of the 1060-degree C sample was clearly insufficient.

[0017] (Example 2 of a comparison) Coarse grinding was carried out like the example 1 using Alloy R and Alloy S which were shown in Table 1, and pulverizing, sintering, and heat treatment were performed after mixing so that it might become the last presentation. Here, Co and Cu were uniformly added into both alloys, and Dy was added into Alloy S. Magnetic properties are measured

after observing the appearance of the obtained sintered compact, and the result of magnetic properties when square shape nature is the highest, sintering temperature, and appearance observation is shown in Table 1. Hcj was lower than the example 1, and the big and rough grain was observed.

[0018] (Example 3 of a comparison) Coarse grinding was carried out like the example 1 using Alloy C and Alloy Q which were shown in Table 1, and pulverizing, sintering, and heat treatment were performed after mixing so that it might become the last presentation. Here, Dy, Co, and Cu were added into Alloy Q, and B added both alloys uniformly. Magnetic properties are measured after observing the appearance of the obtained sintered compact, and the result of magnetic properties when square shape nature is the highest, sintering temperature, and appearance observation is shown in Table 1. Hcj was lower than the example 1, and the big and rough grain was observed although it was fewer than the examples 1 and 2 of a comparison.

[0019] (Example 2) Coarse grinding was carried out like the example 1 using Alloy A and Alloy K which were shown in Table 1, and pulverizing, sintering, and heat treatment were performed after mixing so that it might become the last presentation. Here, Dy, Co, and Cu were added into Alloy K, and B could be 0.4mass(es)%. Alloy K is the 2nd alloy of this invention. Magnetic properties are measured after observing the appearance of the obtained sintered compact, and the result of magnetic properties when square shape nature is the highest, sintering temperature, and appearance observation is shown in Table 1. The good value was acquired by magnetic properties like the example 1, sintering temperature is 1100 degrees C at this time, and the big and rough grain etc. was not seen.

[0020] (Example 3) Coarse grinding was carried out like the example 1 using Alloy A and Alloy L which were shown in Table 1, and pulverizing, sintering, and heat treatment were performed after mixing so that it might become the last presentation. Here, Dy, Co, and Cu were added into Alloy L, and B could be 0.7mass(es)%. Alloy L is the 2nd alloy of this invention. Magnetic properties are

measured after observing the appearance of the obtained sintered compact, and the result of magnetic properties when square shape nature is the highest, sintering temperature, and appearance observation is shown in Table 1. The good value was acquired by magnetic properties like the example 1, sintering temperature is 1100 degrees C at this time, and the big and rough grain etc. was not seen.

[0021] (Example 4) Coarse grinding was carried out like the example 1 using Alloy B, Alloy C, and Alloy I which were shown in Table 1, and pulverizing, sintering, and heat treatment were performed after mixing so that it might become the last presentation. Here, Dy, Co, and Cu were added into Alloy I, and B was taken as additive-free. Alloy I is the 2nd alloy of this invention. Magnetic properties are measured after observing the appearance of the obtained sintered compact, and the result of magnetic properties when square shape nature is the highest, sintering temperature, and appearance observation is shown in Table 1. The good value was acquired by magnetic properties like the example 1, sintering temperature is 1100 degrees C at this time, and the big and rough grain etc. was not seen.

[0022] (Example 5) Coarse grinding was carried out like the example 1 using Alloy B, Alloy C, Alloy D, and Alloy J which were shown in Table 1, and pulverizing, sintering, and heat treatment were performed after mixing so that it might become the last presentation. Here, Co and Cu were added into Alloy J and B was taken as additive-free. Alloy J is the 2nd alloy of this invention. Dy was added with the alloy D which is one of the 1st alloy of this invention. Magnetic properties are measured after observing the appearance of the obtained sintered compact, and the result of magnetic properties when square shape nature is the highest, sintering temperature, and appearance observation is shown in Table 1. The good value was acquired by magnetic properties like the example 1, sintering temperature is 1100 degrees C at this time, and the big and rough grain etc. was not seen.

[0023] (Example 4 of a comparison) Coarse grinding was carried out like the

example 1 using Alloy T and Alloy U which were shown in Table 1, and pulverizing, sintering, and heat treatment were performed after mixing so that it might become the last presentation. here -- Dy, Co, and Cu -- R -- it added into the rich alloy U and B was taken as additive-free. Alloy U is not the 2nd alloy of this invention. Magnetic properties are measured after observing the appearance of the obtained sintered compact, and the result of magnetic properties when square shape nature is the highest, sintering temperature, and appearance observation is shown in Table 1. The good value was acquired by magnetic properties like the example 1, sintering temperature is 1100 degrees C at this time, and the big and rough grain etc. was not seen. This result shows that the magnetic properties acquired in the examples 1-5 are equivalent to two conventional alloying methods (example 4 of a comparison).

[0024] (Examples 6-10, examples 5-8 of a comparison) the -- one -- an alloy -- A-D -- the -- two -- an alloy -- I-L -- a comparison -- ** -- an alloy -- P-U -- a presentation -- setting -- Ga -- 0.1 -- mass(es) -- % -- having added -- an alloy -- new -- producing -- the -- one -- an alloy -- A -- ' - D -- ' -- the -- two -- an alloy -- I -- ' - L -- ' -- a comparison -- ** -- an alloy -- P -- ' - U -- ' -- ** -- having carried out . The sintered compact was produced by the same approach as examples 1-5 and the examples 1-4 of a comparison, and magnetic properties were measured after observing the appearance of a sintered compact. The result of magnetic properties when square shape nature is the highest, sintering temperature, and appearance observation is shown in Table 2. About the optimal sintering temperature and the appearance of a big and rough grain, although it is the same as that of the result of Table 1, it can check that the level of Hcj carries out improvement in 0.2 MA/m extent. The compound addition effectiveness of Ga has shown up.

[0025]

[Table 1]

		組　成 (mass%)							
		Nd	Pr	Dy	TRE	B	Co	Cu	Fe
第1合金	A	25.3	7.0	0	32.3	1.00	0	0	bal.
	B	25.2	7.0	0	32.2	1.07	0	0	bal.
	C	25.3	7.0	0	32.3	0.90	0	0	bal.
	D	11.9	3.3	17.0	32.2	1.07	0	0	bal.
第2合金	I	18.6	5.2	8.5	32.3	0	20	1	bal.
	J	25.3	7.0	0	32.3	0	20	1	bal.
	K	20.8	5.7	5.7	32.2	0.4	13.3	0.67	bal.
	L	23.1	6.4	2.8	32.3	0.7	6.7	0.34	bal.
比較合金	P	24.6	6.85	0.85	32.3	0.90	2	0.1	bal.
	Q	18.5	5.2	8.5	32.2	0.90	20	1	bal.
	R	25.3	6.9	0	32.2	0.90	2	0.1	bal.
	S	12.0	3.3	17.0	32.3	1.07	2	0.1	bal.
	T	23.8	6.6	0	30.4	1.03	0	0	bal.
	U	30.1	8.4	7.2	45.7	0	16.9	0.85	bal.
最終組成		24.6	6.85	0.85	32.3	0.90	2	0.1	bal.

Al:0.06～0.08mass%

	配合(合金×配合率)	Br (T)	Hcj (MA/	Hk/Hc (%)	最適焼温度	粗大粒外観
実施例	A×0.9+I×0.1	1.36	1.17	98.3	1100	○
比較例	P	1.35	1.01	98.1	1080	×
比較例	R×0.95+S×0.05	1.35	1.0	98.2	1080	×
比較例	C×0.9+Q×0.1	1.35	1.03	98.1	1080	△
実施例	A×0.85+K×0.15	1.35	1.16	98.0	1100	○
実施例	A×0.7+L×0.3	1.36	1.16	97.8	1100	○
実施例	B×0.53+C×0.37+I×0.1	1.35	1.17	98.2	1100	○
実施例	B×0.5+C×0.35+D×0.05+J	1.36	1.17	98.4	1100	○
比較例	T×0.88+U×0.12	1.36	1.18	98.1	1100	○

○:なし　△:あり　×:多し

[0026]

[Table 2]

	配合(合金×配合率)	Br (T)	Hcj (MA/	Hk/Hc (%)	最適焼温度	粗大粒外観
実施例	A'×0.9+I'×0.1	1.35	1.38	98.4	1100	○
比較例	P'	1.34	1.21	97.9	1080	×
比較例	R'×0.95+S'×0.05	1.35	1.22	97.9	1080	×
比較例	C'×0.9+Q'×0.1	1.35	1.25	98.4	1080	△
実施例	A'×0.85+K'×0.15	1.35	1.37	98.2	1100	○
実施例	A'×0.7+L'×0.3	1.35	1.35	98.1	1100	○
実施例	B'×0.53+C'×0.37+I'×0.1	1.35	1.38	98.4	1100	○
実施例	B'×0.5+C'×0.35+D'×0.05+	1.36	1.37	98.4	1100.	○
比較例	T'×0.88+U'×0.12	1.35	1.38	98.4	1100	○

○:なし　△:あり　×:多し

[0027]

[Effect of the Invention] According to this invention, in the approach of adding Co, Cu, Dy, etc., it can utilize enough, without changing the raw material alloy of the

conventional amount of rare earth in any way, generating of the big and rough crystal grain at the time of sintering and the fall of coercive force cannot be invited, but high magnetic properties can be attained.

[Translation done.]